(54) **Method for improving performances of a mobile radiocommunication system using convergence assessment of power control loop**

(57) A method for improving performances of a mobile radiocommunication system using a power control loop (1) which controls power according to a transmission quality target value, and an adjustment process (2) for adjusting said transmission quality target value, a method wherein said adjustment process is controlled (4) based on an assessment (3) of the convergence of said power control loop around said transmission quality target value.
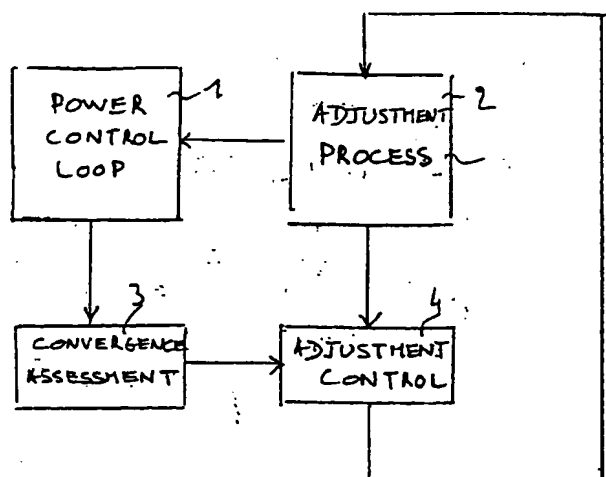
Fig. 1

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Description

[0001]   The present invention is generally concerned with mobile radiocommunication systems.

[0002]   The present invention is more particularly concerned with power control used in such systems to improve performances (in terms of quality of service, of capacity,...etc.).

[0003]   The present invention is in particular applicable to mobile radiocommunication systems of CDMA ("Code Division Multiple Access") type. In particular, the present invention is applicable to UMTS ("Universal Mobile Telecommunication System").

[0004]   One type of power control which is used in CDMA systems is the so-called closed-loop power control.

[0005]   The closed loop generally runs on a fast basis in order to adjust the transmission quality (generally represented by the SIR, or "Signal-to-Interference Ratio") around a transmission quality target value (generally a SIR_{target} value), by sending appropriate power control commands back to the transmitter. The closed loop thus sends an "up" power control command back to the transmitter when the estimated SIR is below the SIR_{target} value, or a "down" power control command otherwise.

[0006]   The SIR_{target} value is generally adjusted by a so-called outer loop. The outer loop generally runs on a slower basis in order to adjust the quality of service (generally represented by the BER, or "Bit Error Rate", or the FER, or "Frame Error Rate") around a quality of service target value (generally a BER or FER target value). The outer loop thus increases the SIR_{target} value when an estimated BER or FER is above a BER or FER target value, or reduces it otherwise.

[0007]   Such an implementation may lead to such situations where the SIR_{target} value is needlessly increased, therefore needlessly increasing the interference level in the system.

[0008]   This may in particular be the case under such conditions as when the transmitter has already reached its maximum transmit power, or when the system has become overloaded. In such a case the SIR_{target} value is uselessly increased, while this cannot result in any quality improvement. This may not be considered as a drawback in itself, as long as such conditions apply, but the SIR_{target} value may therefore reach a too high value, and, when such conditions no longer apply, this will result in setting the transmit power at a level higher than necessary, therefore needlessly increasing the interference level in the system, until the algorithm reaches a correct value again.

[0009]   The outer loop is usually implemented at the receiver side, in order to reduce adaptation delays between quality measurements and SIR_{target} setting. However, the receiver may not have means to know why the quality of service cannot be maintained with the current SIR_{target} value, and, as indicated above, may try to increase it, even though the current SIR_{target} value cannot be reached due to network overload for instance.

[0010]   Therefore there is a need to provide a power control method avoiding such drawbacks.

[0011]   An object of the present invention is therefore a method for improving performances of a mobile radiocommunication system using a power control loop which controls power according to a transmission quality target value, and an adjustment process for adjusting said transmission quality target value, a method wherein said adjustment process is controlled based on an assessment of the convergence of said power control loop around said transmission quality target value.

[0012]   According to another object of this invention, said control of said adjustment process includes not performing any adjustment, if said power control loop has not converged around said transmission quality target value.

[0013]   According to another object of this invention, convergence of said power control loop is assessed by determining if a difference between an estimated average transmission quality and said transmission quality target value is within given margins.

[0014]   According to another object of this invention, said margins ore determined so as to take into account power control errors.

[0015]   According to another object of this invention, said margins are optimised according to radio conditions.

[0016]   According to another object of this invention, said margins are different depending on whether said adjustment requires increasing or reducing said transmission quality target value.

[0017]   According to another object of this invention, said estimated average transmission transmission quality is estimated on an averaging period which is long enough to enable said power control loop to converge, but not too long to take into account fast changes in power control requirements.

[0018]   According to another object of this invention, said averaging period is optimised according to radio conditions.

[0019]   According to another object of this invention, convergence of said loop is assessed by determining if, among successive values representative of an estimated average transmission quality, at least one of these values is above said transmission quality target value and at least one of these values is below said transmission quality target value.

[0020]   According to another object of this invention, said transmission quality is represented by a Signal-to-Interference Ratio (SIR).

[0021]   According to another object of this invention, said adjustment process is an outer loop which adjusts a qual-

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ity of service around a quality of service target value.

[0022] According to another object of the invention, said mobile radiocommunication system is of CDMA type.

[0023] According to another object of the invention, said power control is performed in an uplink transmission direction of said mobile radiocommunication system, using an uplink power control loop and an uplink adjustment process, and said uplink adjustment process is controlled, based on an assessement of the convergence of said uplink power control loop.

[0024] According to another object of the invention, said power control is performed in a downlink transmission direction of said mobile radiocommunication system, using a downlink power control loop and a downlink adjustment process, and said downlink adjustment process is controlled, based on an assessement of the convergence of said downlink power control loop.

[0025] The present invention also has for its object a mobile radiocommunication network for performing such a method, said mobile radiocommunication network comprising means for performing said uplink power control loop, means for performing said uplink adjustment process, and means for controlling said uplink adjustment process, based on an assessment of the convergence of said uplink power control loop.

[0026] According to another object of this invention, said mobile radiocommunication network is of the type comprising at least one base station, comprising means for performing said uplink power control loop, and at least one base station controller, comprising means for performing said uplink adjustment process.

[0027] According to another object of this invention, a base station of such a network comprises:

- means for performing measurements necessary for the assessment of the convergence of said uplink power control loop,
- means for sending such measurements to a base station controller.

[0028] According to another object of this invention, a base station controller of such a network comprises:

- means for receiving such measurements from a base station,
- means for assessing the convergence of said uplink power control loop, based on such measurements , and for controlling said uplink adjustment process, based on this assessment.

[0029] The present invention also has for its object a mobile station for performing such a method, said mobile station comprising means for performing said downlink power control loop, means for performing said downlink adjustment process , and means for controlling said downlink adjustment process, based on an assessment of the convergence of said downlink power control loop.

[0030] According to another object of this invention, such a mobile station comprises:

- means for performing measurements necessary for the assessment of the convergence of said downlink power control loop,
- means for assessing the convergence of said downlink power control loop, based on such measurements, and for controlling said downlink adjustment process, based on this assessment.

[0031] According to another object of this invention, such a mobile station further comprises means for receiving parameters required for said assessment of convergence of said downlink power control loop, from a mobile radiocommunication network.

[0032] These and other objects of the present invention will become more apparent from the following description taken in conjunction with the accompanying drawings:

- figure 1 is a diagram intended to illustrate a method according to the invention,
- figure 2 is a diagram intended to illustrate the general architecture of the radio access network, or "UTRAN" ("UMTS Terrestrial Radio Access Network"), of UMTS system,
- figure 3 is a diagram intended to illustrate an example of means which may be used in an entity like a base station or Node B of UTRAN, and in an entity like a base station controller or SRNC of UTRAN, to perform a method according to the present invention, for uplink power control,
- figure 4 is a diagram intended to illustrate an example of means which may be used in a mobile station, or user equipment (UE) to perform a method according to the present invention, for downlink power control.

[0033] The present invention thus has for its object a method for improving performances of a mobile radiocommunication system using a power control loop which controls power according to a transmission quality target value, and an adjustment process for adjusting said transmission quality target value, a method wherein said adjustment process

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is controlled, based on an assessment of the convergence of said power control loop around said transmission quality target value.

[0034]   Such a method may be illustrated by the diagram of figure 1, where:

- 1 refers to a power control loop,
- 2 refers to said adjustment process,
- 3 refers to an assessment of the convergence of said power control loop,
- 4 refers to a control of said adjustment process, based on said assessment.

[0035]   Generally, such a method enables to optimise performances, by optimising the adjustment process.

[0036]   In particular, by providing that no adjustment of the transmission quality target value is performed if said power control loop has not yet converged around this target value, this enables to avoid the above mentioned drawbacks.

[0037]   Still in particular, by considering the current case where the adjustment process is the outer loop algorithm as mentioned above, and the power control loop is the closed loop as mentioned above, this may be expressed by the following algorithm:

[0038]   If outer loop algorithm requests a change of SIR_{target},

If closed loop power control has converged, the request is accepted
Else the request is rejected.

[0039]   An example of implementation of such an algorithm may be expressed as follows:

$$\text{If } (Avgd\_FER < FER_{target}) \text{ and } (| SIR_{av} - SIR_{target}| < \eta), SIR_{target} = SIR_{target} - SIR_{dec\_step}$$

$$\text{if } (Avgd\_FER > FER_{target}) \text{ and } (| SIR_{av} - SIR_{target}| < \varepsilon), SIR_{target} = SIR_{target} + SIR_{inc\_step}$$

[0040]   In this example SIR_{inc_step} and SIR_{dec_step} are the specified steps for updating (increasing, respectively decreasing) SIR_{target} values.

[0041]   In this example $(Avgd\_FER < FER_{target})$ or $(Avgd\_FER > FER_{target})$ are the conditions in which the outer loop requests updating SIR_{target}, where:

- $Avgd\_FER$ is a measured FER averaged over a given period. Other quality parameters could be used such as Block Error Rate, number of retransmissions of PDU in RLC for packet services, etc.
- FER_{target} is the FER target value specified for the bearer service (given at call or session set up).

[0042]   In this example, convergence of the power control closed loop is assessed by determining if the difference between an estimated average transmission quality and said transmission quality target value is within given margins, i.e. if

$$(| SIR_{av} - SIR_{target} | < \eta) \text{ or } (| SIR_{av} - SIR_{target} | < \varepsilon)$$

where:

- SIR_{target} is the SIR target value set by the outer loop algorithm and used by the closed loop power control
- SIR_{av} is the SIR measured and averaged over a given averaging period. This averaging period is a parameter of the system that may be optimised according to radio conditions. It should start at least after the last change in SIR_{target} value, should be long enough to allow the closed loop to reach the new value, but should not be too long to identify fast changes in case of overload situations for instance
- ε, η are margins related to the difference between SIR_{av} measurements and SIR target values (for the case where SIR_{target} needs to be increased, respectively decreased), taking into account power control errors. These parameters may also be optimised according to radio conditions.

[0043]   Other examples may be envisaged to assess the convergence of the closed loop power control. For instance, it may be considered that the closed loop has converged, when among successive values of SIR_{av}, at least one of these values is below SIR_{target} and at least one of these values is above SIR_{target}.

[0044]   Besides, it should be noted that parameters other than SIR might be used to assess the convergence of the closed loop power control, to take into account non precise measurements in case of bad SIR estimation (for low SIR

values in particular).

[0045]   The present invention may be applied to uplink power control, downlink power control, or both uplink and downlink power control.

[0046]   As compared to known methods, the method according to the invention may require additional measurements as well as additional signalling to be performed.

[0047]   As an example, an application of the present invention to the UTRAN architecture of UMTS will be disclosed in the following.

[0048]   As recalled in figure 2, the current UTRAN architecture comprises:

- base stations, called "Node B", which communicate with mobile stations or "User Equipments" (UE) via a radio interface called "Uu",
- base station controllers, called "Radio Network Controllers" or RNC, which communicate with Nodes B via an interface called "Iub" (each RNC controlling a plurality of Nodes B).

[0049]   Within this architecture, for uplink power control the closed loop is currently implemented in Node B, while the outer loop is currently implemented in RNC; for downlink power control both loops are currently implemented in UE.

[0050]   A method according to the invention may then require additional measurements to be performed, in Node B for uplink power control and in UE for downlink power control, as well as additional signalling to be performed between Node B and RNC at the interface Iub, for uplink power control.

[0051]   As illustrated at figure 3, a Node B may therefore comprise, besides other means which may be classical and which are not mentioned here:

- means 10 for performing measurements required for the assessment of convergence of the uplink power control loop,
- means 11 for sending such measurements to RNC.

[0052]   As illustrated at figure 3, a RNC may therefore comprise, besides other means which may be classical and which are not mentioned here:

- means 13 for receiving such measurements from Node B,
- means 14 for assessing the convergence of said uplink power control loop, based on such measurements, and for controlling the uplink adjustment process, or uplink outer loop, based on this assessment.

[0053]   Means like 10, 11, 13, 14 work together so as to perform the above disclosed method, for uplink power control. Such means do not need to be more fully disclosed than by their above disclosed function, for a person skilled in the art. Besides, the required signalling may be performed according to known types of signalling procedures in such types of systems, and therefore does not either require to be more fully disclosed, for a person skilled in the art.

[0054]   For example, the measurements required for the assessment of convergence, and sent by Node B to RNC across the Iub interface, may be sent in band with data PDU ("Packet Data Unit") or out of band.

[0055]   For example, such measurements as SIR_{av} (such as SIR averaged over the transmission time period of a data frame) may be sent in band for each uplink data frame.

[0056]   As illustrated at figure 4, a User Equipment UE may comprise, besides other means which may be classical and which are not mentioned here:

- means 15 for performing measurements required for the assessment of convergence of the downlink power control closed loop,
- means 16 for assessing said convergence, based on such measurements, and for controlling the downlink adjustment process, or downlink outer loop, based on this assessment.

[0057]   No additionnal signalling is therefore required for downlink power control.

[0058]   However, parameters necessary for the assessment of convergence, such as for instance parameter ϵ referred to in the above disclosed example may need to be signalled to each UE, in case network control on said downlink adjustment control would be needed. Alternatively, parameter ϵ for instance may be evaluated by the UE from past measurements.

[0059]   Means like 15, 16 work together so as to perform the above disclosed method, for downlink power control. Such means do not either require to be more fully disclosed than by their above disclosed function, for a person skilled in the art.

Claims

1. A method for improving performances of a mobile radiocommunication system using a power control loop (1) which control power according to a transmission quality target value, and an adjustment process (2) for adjusting said transmission quality target value, a method wherein said adjustment process is controlled (4) based on on assessment (3) of the convergence of said power control loop around said transmission quality target value.

2. A method according to claim 1, wherein said control of said adjustment process includes not performing any adjustment, if said power control loop has not converged around said transmission quality target value.

3. A method according to claim 1 or 2, wherein convergence of said power control loop is assessed by determining if a difference between an estimated average transmission quality and said transmission quality target value is within given margins.

4. A method according to claim 3, wherein said margins are determined so as to take into account power control errors.

5. A method according to claim 3, wherein said margins are optimised according to radio conditions.

6. A method according to claim 3, wherein said margins are different depending on whether said adjustment requires increasing or reducing said transmission quality target value.

7. A method according to claim 3, wherein said estimated average transmission transmission quality is estimated on an averaging period which is long enough to enable said power control loop to converge, but not too long to take into account fast changes in power control requirements.

8. A method according to claim 3, wherein said averaging period is optimised according to radio conditions.

9. A method according to claim 1 or 2, wherein convergence of said power control loop is assessed by determining if, among successive values representative of an estimated average transmission quality, at least one of these values is above said transmission quality target value and at least one of these values is below said transmission quality target value.

10. A method according to any of claims 1 to 9, wherein said transmission quality is represented by a Signal-to-Interference Ratio (SIR).

11. A method according to any of claims 1 to 10, wherein said adjustment process is an outer loop which adjusts a quality of service around a quality of service target value.

12. A method according to any of claims 1 to 11, wherein said mobile radiocommunication system is of CDMA type.

13. A method according to any of claims 1 to 12, wherein said power control is performed in an uplink transmission direction of said mobile radiocommunication system, using an uplink power control loop and an uplink adjustment process, and wherein said uplink adjustment process is controlled, based on an assessement of the convergence of said uplink power control loop.

14. A method according to any of claims 1 to 12, wherein said power control is performed in a downlink transmission direction of said mobile radiocommunication system, using a downlink power control loop and a downlink adjustment process, and wherein said downlink adjustment process is controlled, based on an assessement of the convergence of said downlink power control loop.

15. A mobile radiocommunication network for performing a method according to claim 13, said mobile radiocommunication network comprising means for performing said uplink power control loop, means for performing said uplink adjustment process, and means for controlling said uplink adjustment process based on on assessment of the convergence of said uplink power control loop.

16. A mobile radiocommunication network according to claims 15, said mobile radiocommunication network being of the type comprising at least one base station, comprising means for performing said uplink power control loop, and

at least one base station controller, comprising means for performing said uplink adjustment process.

17. A base station (Node B) of a mobile radiocommunication network according to claim 16, comprising:

   - means (10) for performing measurements necessary for the assessment of the convergence of said uplink power control loop,
   - means (11) for sending such measurements to a base station controller.

18. A base station controller (RNC) of a mobile radiocommunication network according to claim 16, comprising:

   - means (13) for receiving measurements necessary for the assessment of the convergence of said uplink power control loop, from a base station ,
   - means (14) for assessing the convergence of said uplink power control loop, based on such measurements, and for controlling said uplink adjustment process, based on this assessment.

19. A mobile station for performing a method according to claim 14, said mobile station comprising means for performing said downlink power control loop, means for performing said downlink adjustment process , and means for controlling said downlink adjustment process based on an assessment of the convergence of said downlink power control loop.

20. A mobile station (UE) according to claim 19, comprising:

   - means (15) for performing measurements necessary for the assessment of the convergence of said downlink power control loop,
   - means (16) for assessing the convergence of said downlink power control loop, based on such measurements, and for controlling said downlink adjustment process, based on this assessment.

21. A mobile station according to claim 20, further comprising means for receiving parameters required for said assessment of convergence of said downlink power control loop, from a mobile radiocommunication network.
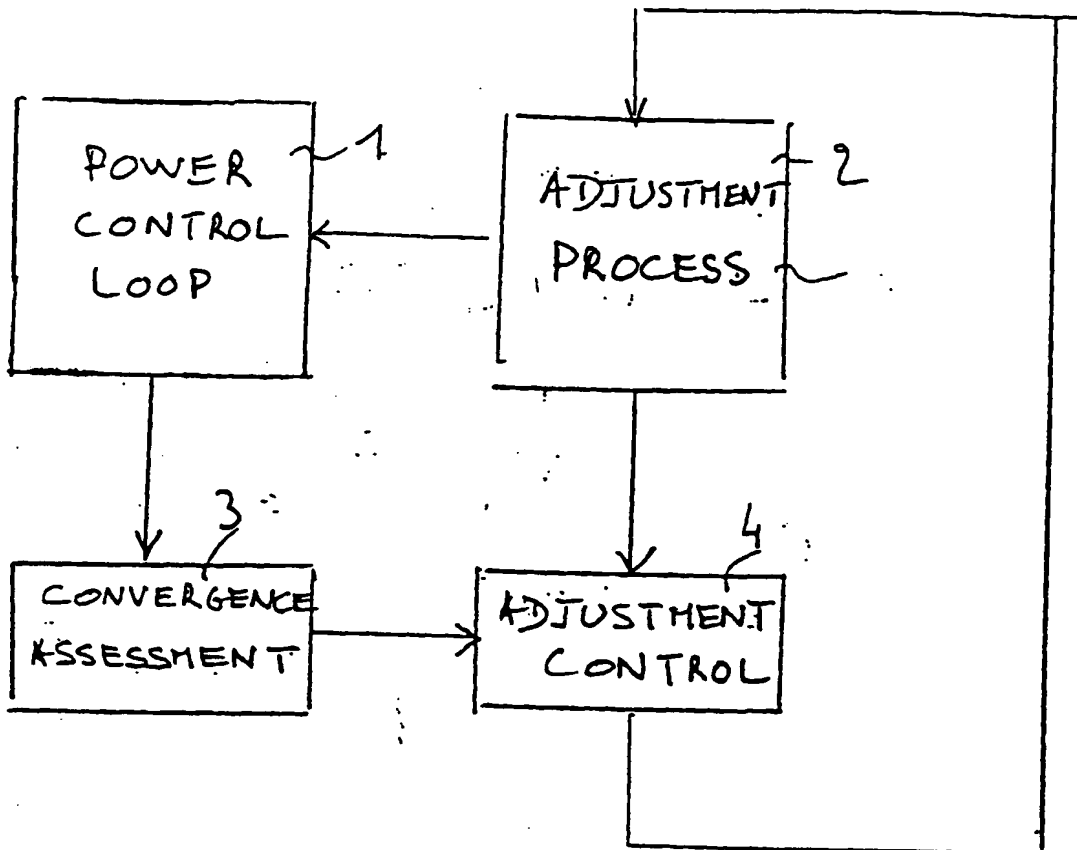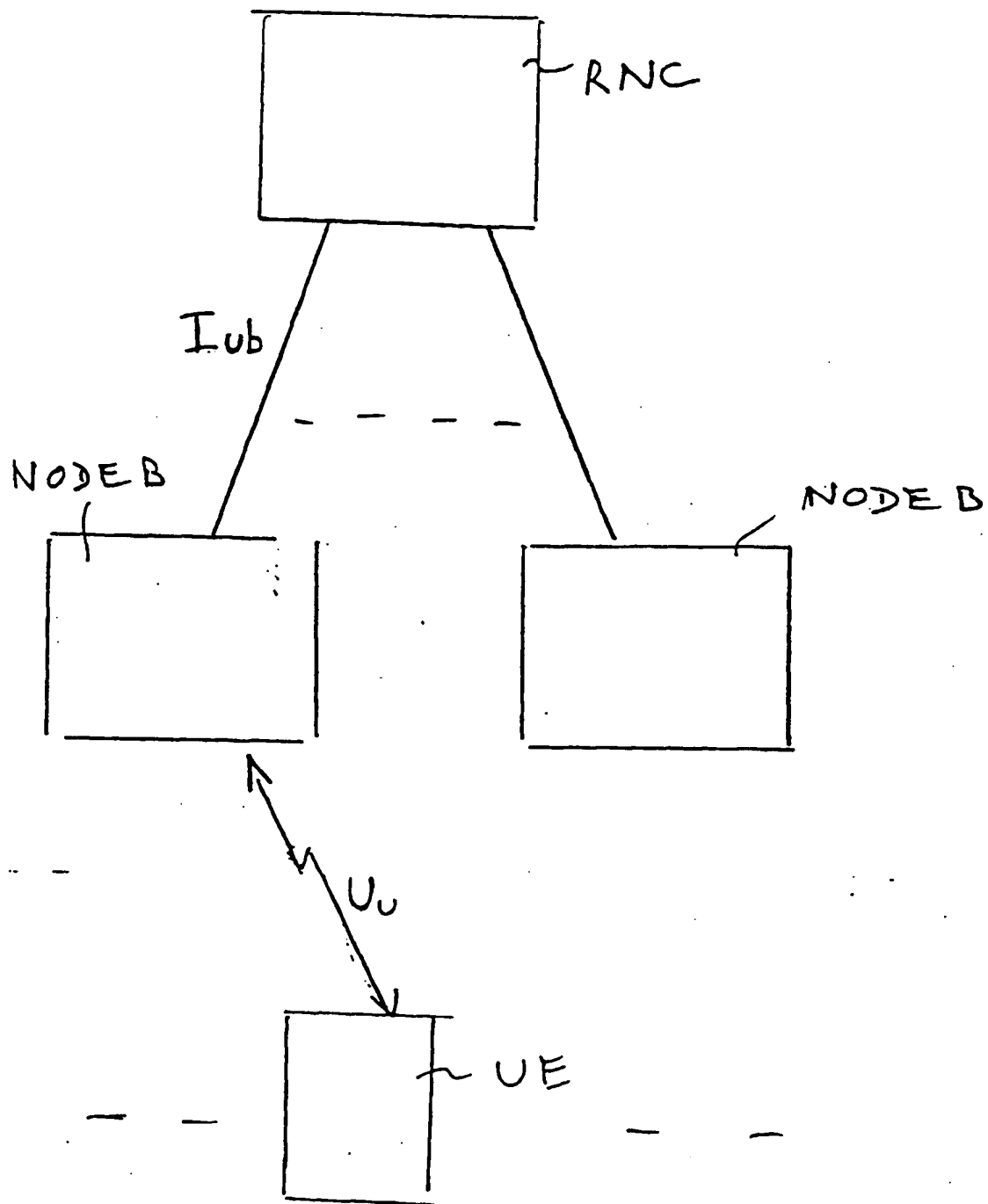
Fig. 1

RNC

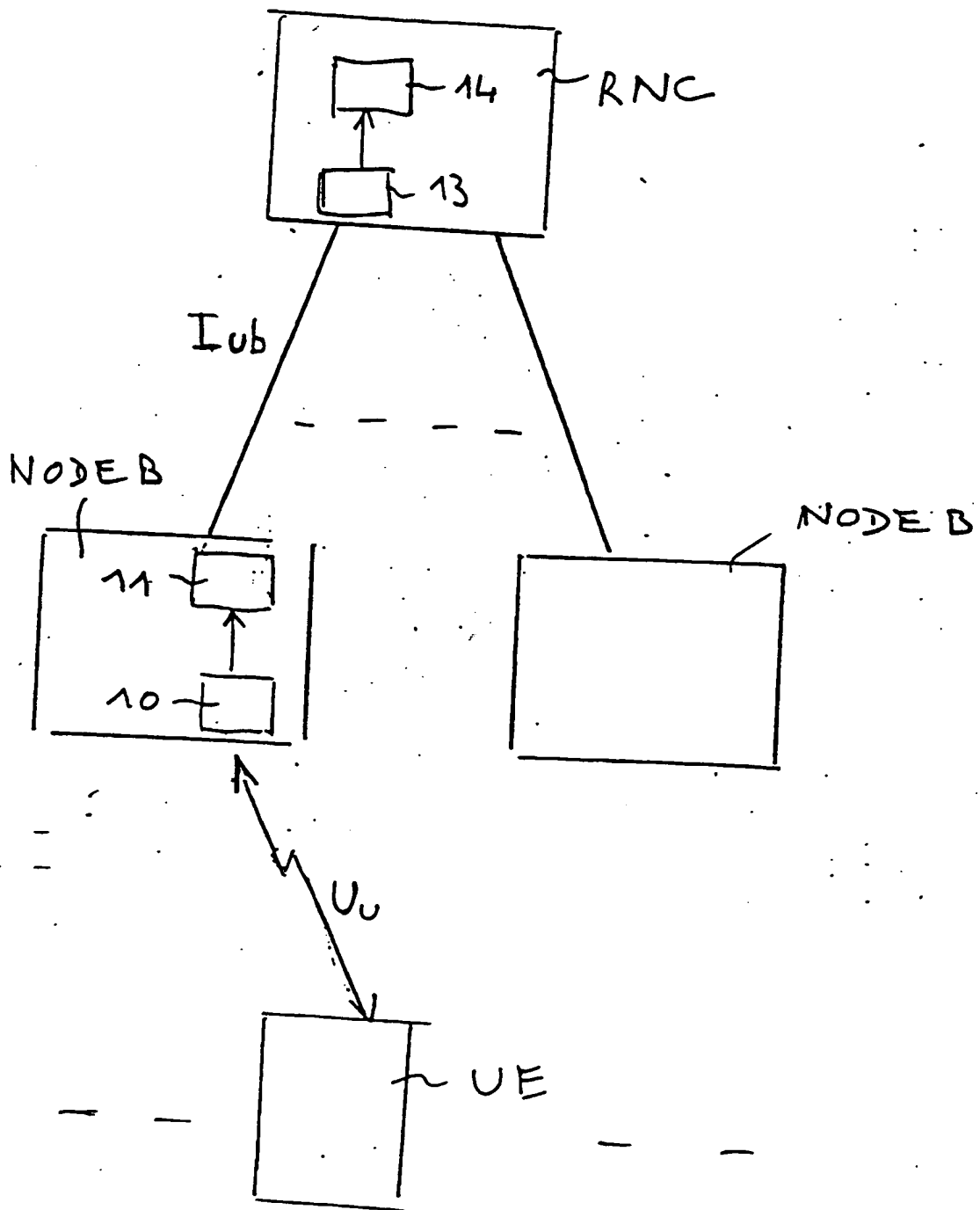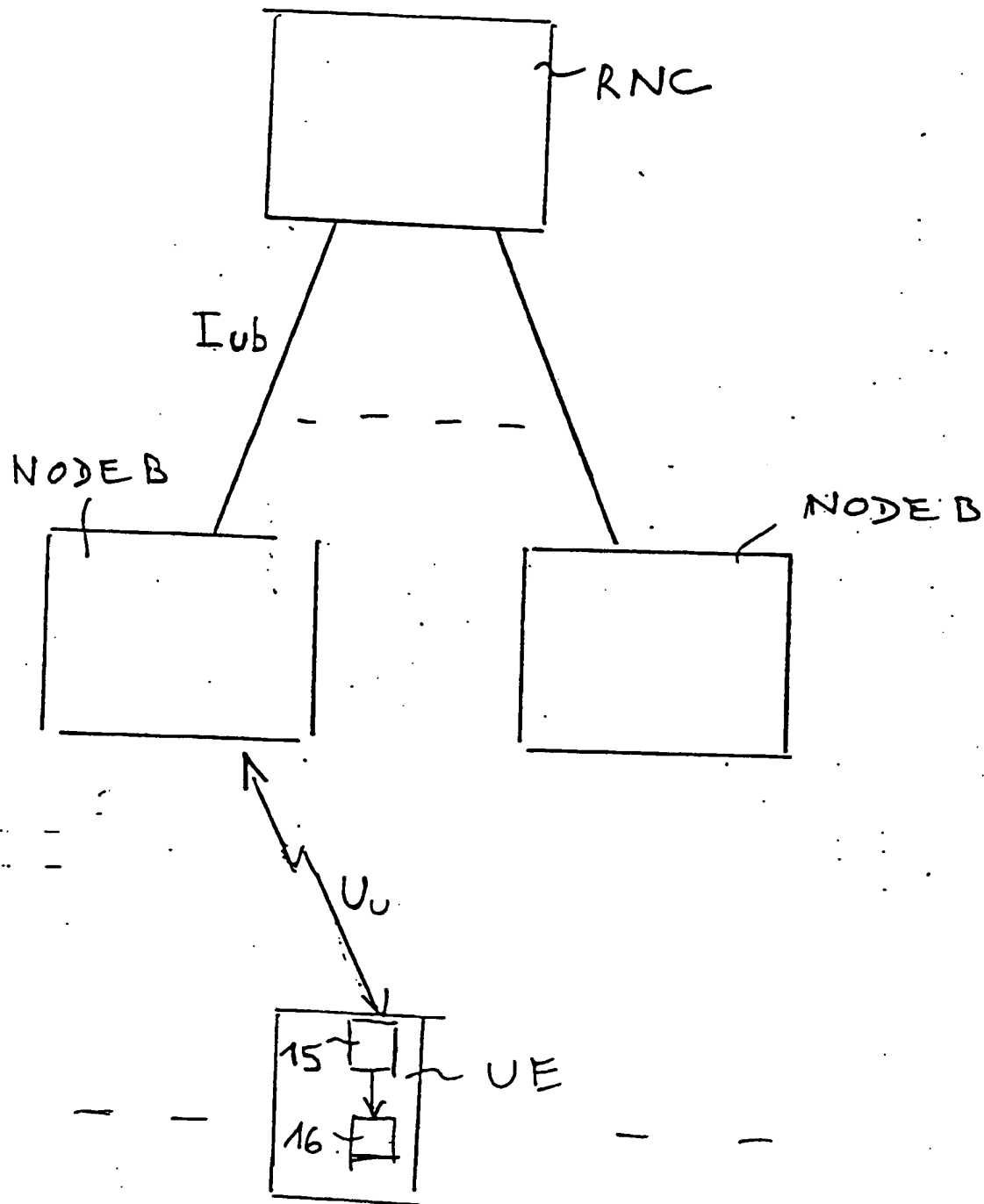Iub

NODE B   NODE B

Uu

UE

Fig. 2

RNC

14

13

Iub

NODE B

11

10

NODE B

Uu

UE

Fig. 3

RNC

Iub

NODE B

NODE B

Uu

15

16

UE

Fig. 4

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EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 February 2000	Sieben, S

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EUROPEAN SEARCH REPORT

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ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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